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Phaeocandelabrum, a new genus of anamorphic fungi to accommodate *Sopagraha elegans* and two new species, *Ph. callisporum* and *Ph. joseiturriagae*

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Abstract — *Phaeocandelabrum* anam. gen. nov. is established to accommodate *Sopagraha elegans*, *Ph. callisporum* sp. nov. found on dead leaves of *Cupania paniculata* (*Sapindaceae)* and on the decaying leaf of an unidentified dicotyledonous plant in Brazil,

and *Ph. joseiturriagae* found on decaying leaves of unidentified dicotyledonous plants in Brazil and Venezuela. *Phaeocandelabrum callisporum* is distinguished by complex, brown conidia composed of 2 globose, brown to dark central cells; 7–10 secondary hemispherical cells and, on each secondary cell, 3–4 hemispherical satellite cells, each with 5 simple, incurved branches. *Phaeocandelabrum joseiturriagae* is characterized by more less broadly Y-shaped to irregular brown conidia, each with a basal cell and two branches composed of 5–7 subglobose to globose cells, with 8–14 secondary cells each subtending 3–5 dichotomous or trichotomous minute tubercles. All three species are described and illustrated.

Key words — tropical rainforest, systematics, conidial fungi

Introduction

Sopagraha elegans (Castañeda 1985) was described from a sample collected on decaying leaves of *Cedrela mexicana* in Cuba. Another collection has been made from the Centro de Investigaciones Costera "La Mancha", Veracruz, Mexico. Two additional taxa congeneric with *S. elegans* were subsequently discovered during study of collections from Venezuela and Brazil. *Phaeocandelabrum* is described to accommodate the three taxa, which are fully described and illustrated herein

Materials and methods

Samples of submerged plant material were collected during expeditions in 2000 through the forest near "Colonia Tovar", Aragua State, Venezuela and in 2002 and 2006 through the "Morro do Corcovado" rainforest, Senhor do Bonfim, and Chapada Diamantina regions of Brazil. Individual collections were placed in paper bags and taken to the laboratory, then incubated in Petri dishes at 25º C placed in a moist chamber composed of plastic containers (50 L capacity) with 200 ml of sterile water plus 2 ml of glycerol, and examined at regular intervals for the presence of microfungi. Mounts were prepared in polyvinyl alcohol-glycerol (8.0 g in 100 ml of water, plus 5 ml of glycerol) and measurements made at a magnification of × 1000. Micrographs were obtained with a Zeiss Axioskop 40 microscope, Leitz Dialux 20 EB microscope and a Jeol JSM-6400 scanning electron microscope using the techniques described previously by Figueras & Guarro (1988).

Taxonomy

Phaeocandelabrum R.F. Castañeda, Gusmão, Guarro & Iturr., **anam. gen. nov.**

MycoBank MB 39222 Figs. 1-8

Coloniae in substrato naturali effusae, nigrae. Mycelium partim superficiale et partim in substrato immersum. Conidiophora macronemata, mononemata, erecta, septata, laevia vel verrucucosa, brunnea, sed dilute brunnea ad usque apicem. Cellulae conidiogenae

hologenosae, uniloculosae, determinatae vel indeterminatae cum pluribus proliferationibus enteroblasticis percurrentibus, in conidiophoris incorporatae. Loci conidiogeni apicales. Secessio conidiorum *rhexolytica.* Conidia *solitaria, pluriramosa, complicata, brunnea vel atrobrunnea, irregularia, pyramidalia, globosa vel in forma plus minusve litterae Graecae upsilon; ex conformationibus: (i) 2–7 cellulis centralibus hemisphaericis, globosis, turbinatis usque ad doliformibus, aequilateralibus vel inaequalibus, brunnneis; (ii) 8–18 alter cellulis hemisphaericis globosis, coronatis vel plus minusve induplicativis, diminutis cum ramulis dichotomis, aspecto lobulatis vel interdum diminutis ramis simplicibus vel dichotome tuberculatis vel lobulatis usque ad radiatis, dilute brunneis vel subhyalinis ad apicem praedita (iii) nonnunquam 2–4 cellulis tertiis similibus conformatis, ex cellulis secundis orientibus.* Synanamorpha *ad genus Selenosporella similis, nonnunquam cellulis conidiogenis, hologenosis, multiloculosis, sympodialibus, indeterminatis in diminutis ramulis dichotome orientibus quae tollunt conidia fusiformia, unicellularia, hyalina. Teleomorphosis ignota.*

Etymology: Greek, *phaeo-*, meaning dark-colored; Latin, *-candelabrum*, referring to a hyphomycete genus (*Candelabrum*).

Species typica: *Phaeocandelabrum elegans* (R.F. Castañeda) comb. nov.

Colonies on the natural substrate effuse, epiphyllous, sometimes amphigenous, hairy, brown or black. Mycelium superficial and immersed. Conidiophores macronematous, mononematous, erect, straight, septate, smooth or verruculose, brown below to pale brown towards the apex. Conidiogenous cells monoblastic, terminal, integrated, determinate or indeterminate with several enteroblastic percurrent proliferations. Conidial secession rhexolytic. Conidia solitary, acrogenous, complex, multi-cellular, branched, irregular, pyramidal, turbinate, globose to Y-shaped, brown to dark brown to dark brown with a basal frill, composed of: i) 2–7 hemispherical, globose, turbinate to doliiform central cells, equilateral or unequal, brown to dark brown ii) 8–18 hemispherical, globose, crowed to induplicate secondary cells with minute dichotomous tubercles or slightly lobed to radial, pale brown to subhyaline, iii) 2–4 hemispherical, crowned or with short dichotomous tubercles tertiary cells sometimes arise from secondary cells. Synanamorph *Selenosporella*-like, arising from the tubercles of tertiary cells. Conidia holoblastic, fusiform, unicellular, hyaline.

Notes. The genera *Arachnophora* Hennebert, *Candelabrum* Beverw., *Polyancora* Voglmayr & Yule and *Sopagraha* Subram. & Sudha can be compared with *Phaeocandelabrum* in conidium ontogeny, the shape of conidia, particularly in terms of the number of cells of the main body, and their ramification and ornamentation. *Arachnophora* is clearly distinguished by a central body with 2 brown to dark brown cells, each of which bears several lateral somewhat conical protuberances which themselves each have 1 or several straight or inwardly curved, pale brown or hyaline arms (Hennebert 1963, Castañeda et al. 1997, Castañeda & Guarro 1998, Becerra et al. 2009). Although conidium ontogeny and conidial secession are similar in both genera, configuration of

the conidia is clearly different from *Phaeocandelabrum*. In *Candelabrum* each conidium consists of a more or less H-shaped main body of 4 to several hyaline to subhyaline, smooth central cells and 8 to many lateral cells which grow centrifugally from each central cell, becoming repeatedly dichotomously or trichotomously branched in 3 dimensions with ultimate cells also dichotomous or trichotomous and subhyaline with minute tubercles (Matsushima 1996, Voglmayr 1998). The genus *Sopagraha* is characterized by conidia with 2–3 dark brown central cells, which produce 4–12 secondary hemispherical, dome-shaped cells called "primary satellite cells" (Subramanian & Sudha 1979), which usually arise from the two upper cells and rarely from the basal cell, and 1–4 hemispherical, hyaline tertiary cells laterally borne from secondary cells called "secondary satellite" cells. The conidial secession is considered to be rhexolytic and Subramanian & Sudha (1979) remarked that the "conidia do not secede from the conidiophores; in fact, detached conidia carry along with them longer or shorter portion of the conidiophores on which they were produced." Conidiophores are macronematous, mononematous, simple or branched and putative conidiogenous cells are discrete and determinate; these features of conidiogenesis separate *Sopagraha* from *Phaeocandelabrum*. *Polyancora,* recently described by Voglmayr & Yule (2006), has multicellular, globose conidia consisting of three distinct elements: (1) repeatedly centrifugally branching globose central cells, (2) an outermost globose cell that gives rise to (3) several much thinner, elongated, radially oriented cylindrical cells branching several times at the tip, the branchlets being very thin, going off at more or less right angles apically from the cylindrical cell, and arched, resulting in branchlet tips often touching other branchlets or other cylindrical cell tips. The schizolytic conidial secession and hyaline or subhyaline structures clearly differentiates *Sopagraha* from *Phaeocandelabrum*.

Phaeocandelabrum elegans (R.F. Castañeda) R.F. Castañeda, Heredia & Saikawa, **comb. nov.** Figs 1–11, 31

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Basionym: *Sopagraha elegans* R.F. Castañeda, Deuteromycotina de Cuba. Hyphomycetes II. p 13 (1985), Instituto de Investigaciones Fundamentales en Agricultura Tropical "Alejandro de Humboldt", Cuba.

Colonies on the natural substrate effuse, epiphyllous, sometimes amphigenous, hairy, brown. Mycelium superficial and immersed. Hyphae septate, branched,

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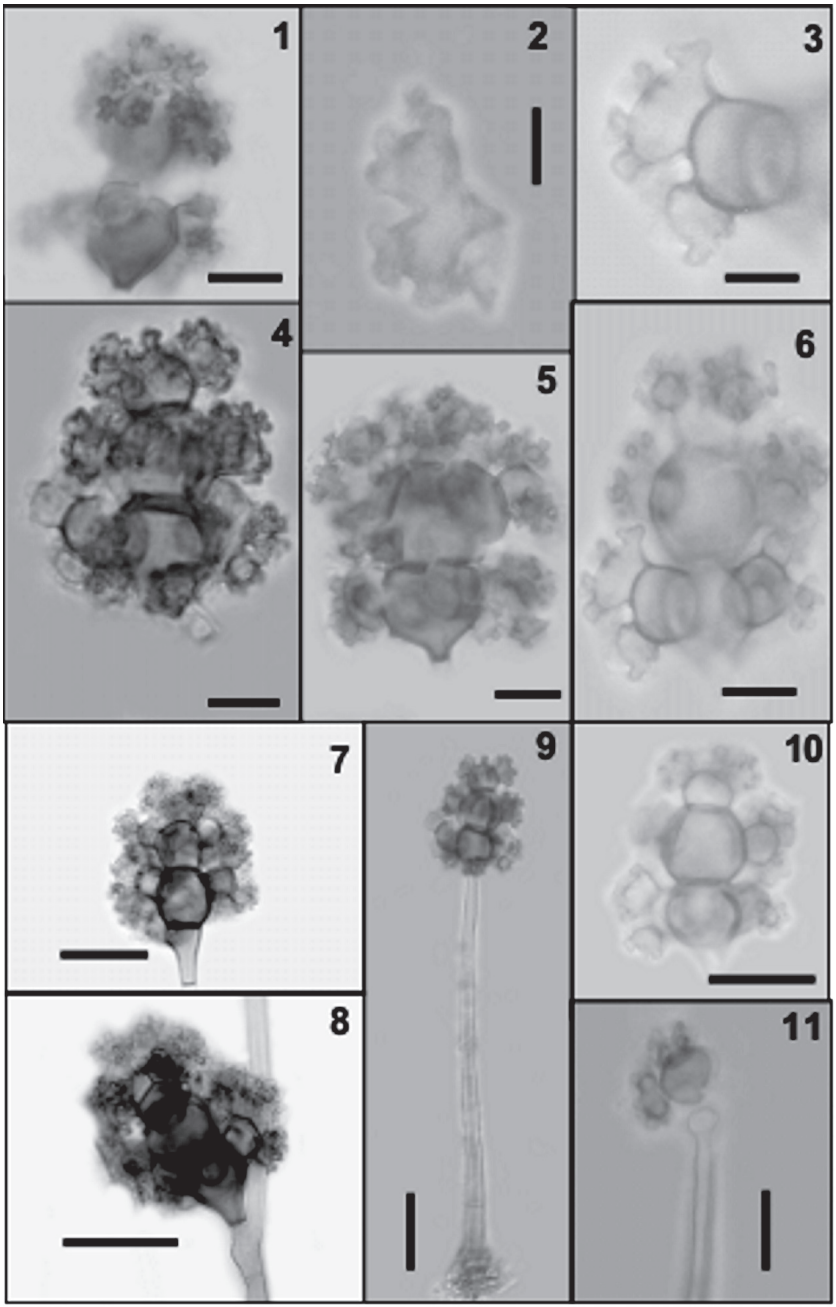
Figs. 1–11. *Phaeocandelabrum elegans*, photomicrographs from holotype (INIFAT C84/97) and XAL CB079–1. Figs. 1–3. Tertiary cells with dichotomous tubercular protuberances. Figs. 4–6, 9–11. Conidiophores and conidiogenous cells and conidia from holotype (INIFAT C84/97). Figs. 7–8. Conidia from (XAL CB079–1).

Scale is indicated by bars. (Figs 1-6: 10 μm, Figs 7,8 and10: 20 μm, Figs 9 and 11: 40 μm).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2.0–3.5 µm diam., smooth-walled, brown. Conidiophores conspicuous, mononematous, erect, straight, 2- to 5-septate, smooth-walled, up to 200 µm tall, 5–7 µm wide, brown below, pale brown towards the apex. Conidiogenous cells monoblastic, terminal, cylindrical, determinate, integrated, sometimes indeterminate with 2 or 3 enteroblastic percurrent proliferations, 14–18 × 2.5–5.0 µm, pale brown, smooth-walled. Conidial secession rhexolytic. Conidia solitary, acrogenous, more less pyramidal, sometimes slightly turbinate, 33–37 × 24–30 µm, brown, dry, with a basal frill 1–2 µm long, complex, composed of: i) 3 globose to hemispherical cells, gradually smaller towards the apex, 10.5–14.5 × 10–12 µm, brown to dark brown, but basal cell somewhat turbinate; ii) 8–12 hemispherical secondary cells, 6–8 µm wide, pale brown to brown; iii) 1–3 tertiary hemispherical cells crowned, 3.5–5 µm wide , with 3–5 short dichotomous tubercles or lobes, pale brown to subhyaline. Synanamorph *Selenosporella*-like, arising from the tubercles of tertiary cells. Conidia holoblastic, fusiform, unicellular, 2.5–4.5 × 0.5–1 µm, hyaline, smooth.

Specimens examined: **CUBA. Ciudad de La Habana**. Santiago de Las Vegas, on decaying leaves of *Cedrela mexicana* M.J. Roem., 16.X.1984. R.F. Castañeda (**HOLOTYPE**: INIFAT C84/97). **MEXICO. Veracruz**, Estación Biológica de la Mancha, Municipio Actopan, Selva mediana, on decaying leaves of an unidentified plant, 2.VIII.1995, G. Heredia (XAL CB079–1).

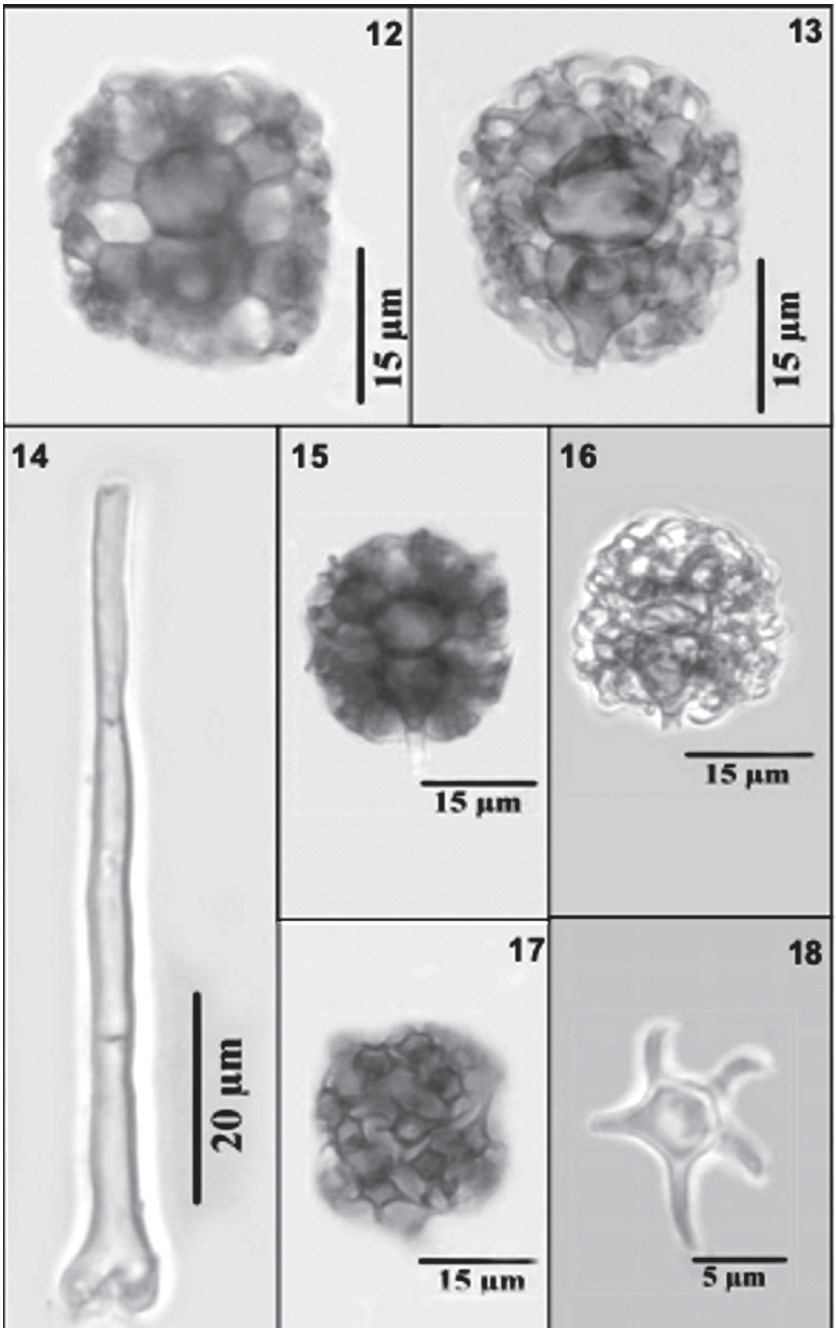
Phaeocandelabrum callisporum Gusmão, A.C. Cruz & R.F. Castañeda, **sp. nov.**
MycoBank MB511005 Figs 12–18, 32

Coloniae in substrato naturali effusae, pilosae, amphigenae, brunneae Conidiophora macronemata, mononemata, 2–6-septata, 67–150 × 6–9 µm, brunnea et pallidiora ad apicem. Cellulae conidiogenae hologenosae, uniloculosae, 14–42 × 2–4 µm, integratae, determinatae vel indeterminatae cum proliferationibus enteroblasticis percurrentibus, pallide brunneis. Conidia solitaria, pluriramosa, complicata, globosa vel bihemisphaerica, plus minusve aequilateralibus, 26–36 × 25–32 µm, brunneis, siccis, compositis ab (i) 2 cellulis hemisphaericis vel globosis, cellula basali licet sit turbinata, 10–13 × 9–13 µm cum reliquiis cellularum conidiogenarum 1.2–6.6 µm; cellula suprabasalis hemisphaerica, 9–12 × 10.2–13.8 µm, brunnea; (ii) 7–10 cellulis secundariis plus minusve doliiformibus, 4–9 × 4–7 µm; iii) 3–4 cellulis hemisphaericis, plus minusve induplicativis, stellatis 9–10 µm diam., cum 5 ramulis radialibus, dilute brunneis vel subhyalinis, circa apicem cellulis secundariis dispositis. Teleomorphosis ignota.

Type: **BRAZIL. Bahia, Palmeiras,** Vale do capão, on decaying leaves of *Cupania paniculata* Cambess. (*Sapindaceae*), 24.VI.2000. L.F.P Gusmão (**HOLOTYPE**: HUEFS 56701).

Etymology: Greek, *calli* - meaning pretty and elegant; - *sporus* - referring to the conidia.

Figs. 12–18. *Phaeocandelabrum callisporum*, photomicrographs from holotype (HUEFS 56701). Figs. 12–13, 15–17. Conidia with a frill. Fig. 14. Conidiophore and conidiogenous cell. Fig. 18. Induplicative, stellate tertiary cell. Scale is indicated by bars.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5 µm

Colonies on the natural substrate effuse, hairy, amphigenous, brown. Mycelium superficial and immersed; hyphae septate, branched, 2.0–3.5 µm diam., smooth-walled, pale brown to brown. Conidiophores macronematous, mononematous, erect, straight, 2- to 6-septate, smooth-walled, 67–150 × 6–9 µm, brown at the base, pale brown towards the apex. Conidiogenous cells monoblastic, terminal, cylindrical, determinate, integrated, 14–42 × 2–4 µm, sometimes indeterminate with 2 enteroblastic percurrent proliferations, pale brown, smooth-walled. Conidia solitary, acrogenous, branched, globose or bi-hemispherical, more less equilateral, 26–36 × 25–32 µm, brown, with turbinate basal cell and a basal frill 1.2–6.6 µm long, complex, composed of: i) 2 brown to dark brown, hemispherical to globose central cells, 10–13 × 9–13 µm; ii) 7–10 pale brown to pale brown, more less doliiform secondary cells, 4–9 × 4–7 µm; iii) 3–4 stellate tertiary hemispherical cells, 9–10 µm diam with 5 radial, subhyaline to pale brown projections. Teleomorph unknown.

Additional specimen examined: **BRAZIL. Bahia**, Senhor do Bonfim, on decaying leaves of an unidentified dicotyledonous plant, 28.IX.2006. A.C.R. Cruz, HUEFS 120873.

Phaeocandelabrum joseiturriagae R.F. Castañeda, Iturr., Heredia & M. Stadler, **sp. nov.** Figs 19–24, 25–30, 33

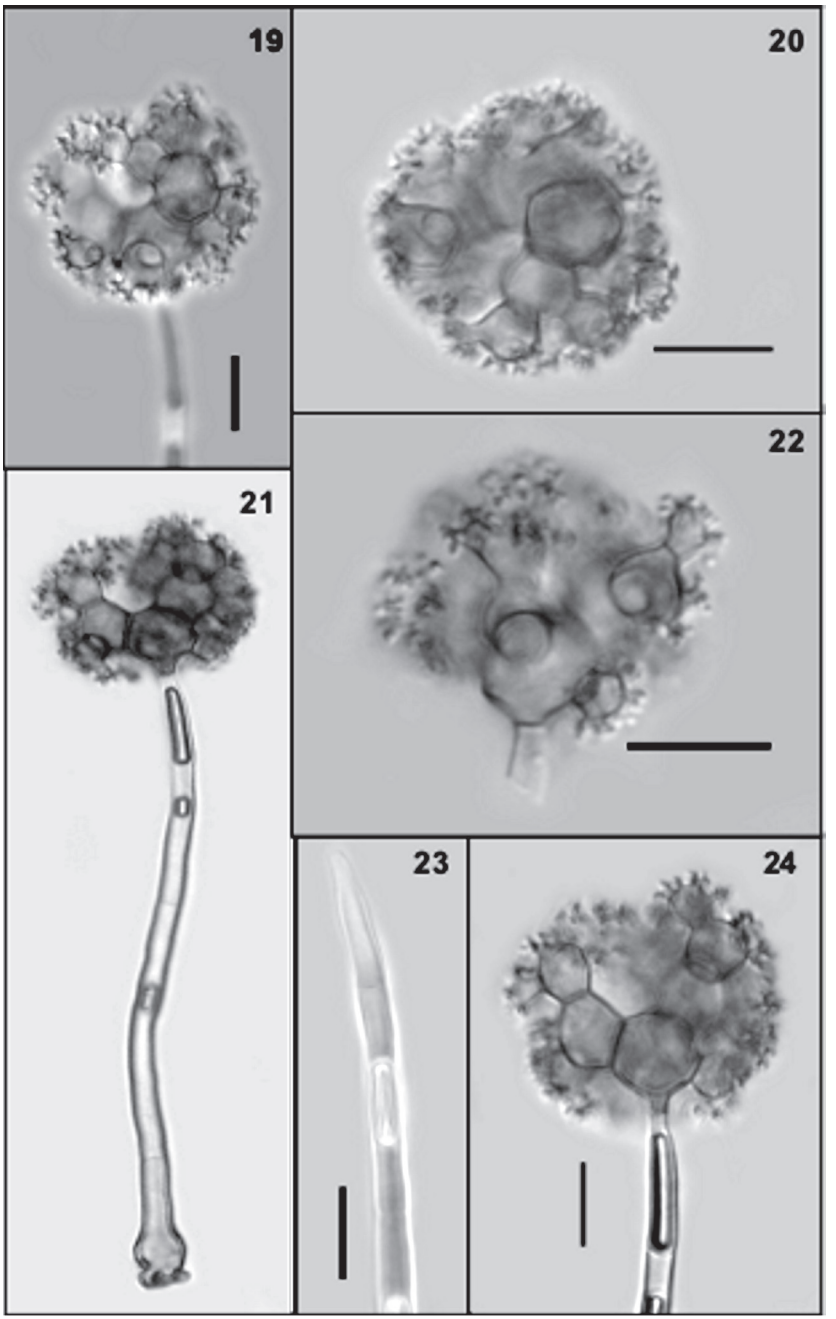
MycoBank MB511004

Coloniae in substrato naturali effusae, pilosae, plerumque hypophyllae, brunneae. Conidiophora macronemata, mononemata, 3- ad 4- septata, 60–110 × 5–7 µm, brunnea. Cellulae conidiogenae hologenosae, uniloculosae, 7.2–12 × 3.6–4.0 µm, integratae, determinatae vel indeterminatae cum proliferationibus enteroblasticis percurrentibus, brunneis et dilute brunneis ad apicem. Conidia solitaria, pluriramosa, complicata, brunnea, irregularia, plus minusve in forma litterae Graecae upsilon, in summa 24–30 × 24.4–33.6 µm, brunnea sed dilute brunnea ad marginem, composita ab: (i) 5–7 cellulis centralibus hemisphaericis ad subglobosis, aequilateralibus vel inaequalibus sed cellulis basalibus turbinatis, 9.6–13.2 × 9.6–14.4 µm, brunneis; cum reliquiis cellulae conidiogenae 1.5–2.6 µm; (ii) 8–14 cellulis secundariis hemisphaericis vel globosis, 7.2–9.6 × 8.4–9.2 µm, cum diminutis tuberculis dichotomis vel trichotomis, dilute brunneis vel subhyalinis ad marginem praeditis; (iii) nonnunquam 2–4 cellulis tertiis similibus conformatis, 6.0–6.6 × 7.0–7.6 µm ex cellulis secundariis orientibus. Teleomorphosis ignota.

Type: **BRAZIL. Rio de Janeiro,** "Morro do Corcovado", on decaying leaves of an unidentified plant, 12.X.2002. J. Guarro and A.M. Stichgel (**HOLOTYPE**: CBS H–6587a).

Etymology: Latin, *joseiturriagae* – in honour of José F. Iturriaga, an important mentor to Venezuelan mycology, and father to T. Iturriaga.

Figs. 19–24. *Phaeocandelabrum joseiturriagae*, photomicrographs from holotype (CBS H–6587a). Figs. 19–21, 24. Conidiophore, conidiogenous cell and conidia. Fig. 22–23. Conidia with a frill and conidiogenous cell. Scale bars 10 µm..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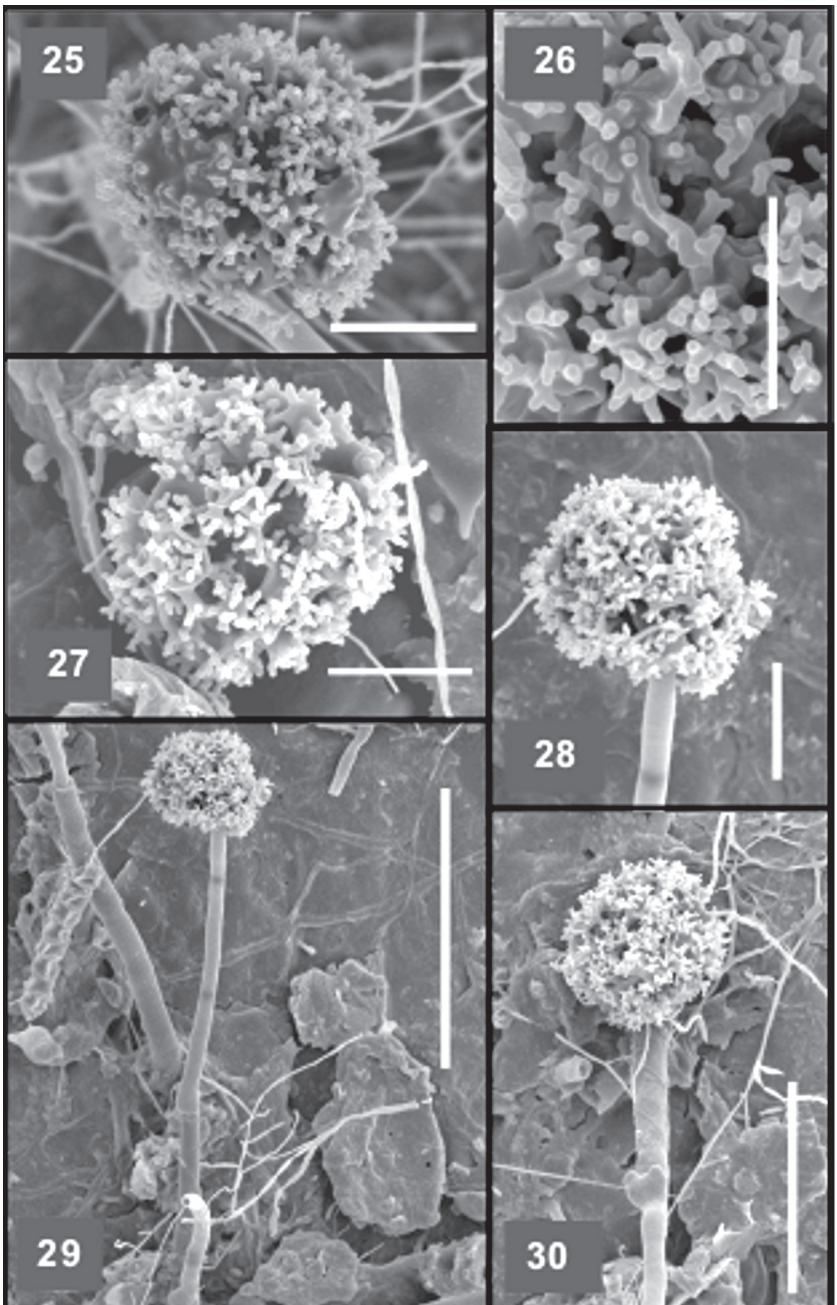
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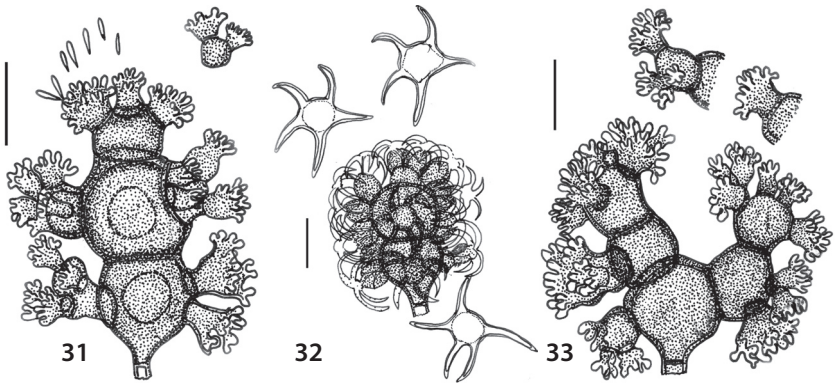

Figs. 31–33. Conidia and tertiary cells in *Phaeocandelabrum* spp. Scale bars = 10 μm.

Fig. 31. *P. elegans* (INIFAT C84/97, holotype). Conidium with *Selenosporella*-like synanamorph and tertiary cell with dichotomous tubercles. Fig. 32. *P. callisporum* (HUEFS 56701, holotype). Conidium and induplicative, stellate tertiary cells. Fig. 33. *P. joseiturriagae* (CBS H–6587a, holotype). Conidium and tertiary cell with dichotomous tubercles.

Colonies on the natural substrate effuse, hairy, mostly hypophyllous, brown. Mycelium superficial and immersed. Hyphae septate, branched, 1.0–2.5 μm diam., smooth-walled, pale brown to brown. Conidiophores macronematous, mononematous, erect, straight or slightly sinuate, 3- to 4-septate, inflated and somewhat lobed at the base, smooth-walled, 60–110 × 5–7 μm, brown below, pale brown towards the apex. Conidiogenous cells monoblastic, terminal, cylindrical, determinate, integrated, sometimes indeterminate with 2–3 enteroblastic percurrent proliferations, 7.2–12 × 3.6–4.0 μm, pale brown, smooth-walled. Conidia solitary, acrogenous, branched, more less broadly Y-shaped to irregular, 24–30 × 24.4–33.6 μm, brown, but pale brown at margin, complex, composed of: i) 5–7 hemispherical to subglobose, equilateral or unequal central cells, 9.6–13.2 × 9.6–14.4 μm, basal cell somewhat turbinate, brown, with a frill 1.5–2.6 μm long; ii) 8–14 hemispherical or globose secondary cells, 7.2–9.6 × 8.4–9.2 μm, pale brown to brown, with 3–5 dichotomous or trichotomous, pale brown to subhyaline minute tubercles at the apex; iii) sometimes 2–4 crowded tertiary hemispherical cells, 6.0–6.6 × 7.0–7.6 μm, arising from the secondary cells with 3–5 dichotomously or trichotomously branched minute tubercles near the apex. Teleomorph unknown.

Figs. 25–30 (left). *Phaeocandelabrum joseiturriagae*, photomicrographs (SEM) from holotype (CBS H–6587a). Figs. 25–26. Conidia showing the tertiary cells with dichotomous or trichotomous tubercles. Figs. 27–30. Conidiogenous cells and conidia.

Scale bars: Figs. 25, 27–28 = 10 μm; Fig 26 = 8 μm; Fig. 29 = 50 μm; Fig. 30 = 30 μm.

Additional specimens examined: **ISOTYPES**: HUEFS120867 and INIFAT C02 /89. **VENEZUELA. Estado Aragua,** "Colonia Tovar", on decaying leaves of an unidentified plant, 25.X1.2000. T. Iturriaga and R.F. Castañeda, USB C00/ 92 = CBS 109477.

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